small to cause ecotype differences in plants common to both sites.

If a hummingbird-pollinated species has a specialist pollinator common to both lower and higher elevations, then selection might favor conformity in flower morphologies to enhance reproductive success. Specialist pollinators rely on specific flower morphologies for visual recognition. Changes in flower structure, such as increased corolla length, might reduce a specialist pollinator's ability to locate the flower and effectively pollinate it. Future studies should investigate pollinator species composition at both elevations at Cerro de la Muerte. If the *Fuchsia* or the Ericaceae species has a specialist pollinator common to both elevations, this may explain the observed conformity in flower morphology.

LITERATURE CITED

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NECTAR PRODUCTION IN DIFFERENT PHENOLOGICAL STAGES OF A HUMMINGBIRD-POLLINATED SHRUB (*FUCHSIA* SP.)

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Abstract (MJG) Flowering plants must allocate resources to different proportions of reproductive structures at different stages in their reproductive cycle. We examined such resource allocation in a species of *Fuchsia* in terms of concentration and volume of nectar per flower among individual plants of differing reproductive phenology. We found no significant association between reproductive stage and volume of nectar per flower nor concentration of nectar per flower. Plants may instead employ a strategy whereby a small but constant number of flowers and volume of nectar are maintained throughout the reproductive cycle to ensure continuous visitation by pollinators.

INTRODUCTION (MJG)

Tropical plants at different stages of their reproductive cycle have differing proportions of buds, open flowers, and fruits, and, therefore, should have different strategies for allocating resources to these structures.

In the early stage of the reproductive cycle, when there are few open flowers, plants should allocate most nutrients to these flowers for the production of rewards for pollinators. Plants in an early stage, therefore, might be expected to have high volume and concentration of nectar in their flowers. In the intermediate stage, the plant has more flowers to support but still needs to attract pollinators. However, the plant cannot afford to allocate a highly concentrated nectar to all of them. Therefore, plants at this stage might be expected to have the same total volume of nectar as those in the early stage, but decreased concentration per flower. When many flowers are open, a pollinator will be rewarded by the overall volume of nectar it encounters in the plant rather than by a high concentration of nectar per flower. Finally, late in the reproductive cycle, both the concentration and volume of nectar per flower should decrease. Most nutrients at this point will be allocated to production of berries and little will be left for production of nectar for the few remaining flowers.

Based on these theoretical considerations, we posed three hypotheses. First, plants in the early stage of their reproductive cycle will have high concentration and volume of nectar in their flowers. Second, plants in the intermediate stage will have the same total volume of nectar as those in the early stage, but concentration per flower will decrease. Third, plants in the late stage of their reproductive cycle will have both decreased volume and concentration of nectar in their flowers. To test these hypotheses, we examined three separate phenological stages, based on relative numbers of reproductive structures present on each plant, and we quantified the amount and concentration of nectar found in flowers.

METHODS (NDP)

We studied a hummingbird-pollinated shrub, *Fuchsia* sp., common at high elevations in Costa Rica. This plant grows individually or in large patches along forest edges and roadsides. We sampled along the road south of the Albergue Querici near Cerro de la Muerte, Costa Rica, to examine differences in nectar production between reproductive phenological classes.

We quantified the total number of unopened buds, open flowers, and berries for each of five individual *Fuchsia* plants. To

calculate these values, we first counted the number of unopened buds, open flowers, and berries in a single inflorescence on each plant. We then multiplied each of these values by the total number of similar sized inflorescences on each plant until we obtained totals for each of the five plants.

To classify each plant into a phenological reproductive stage, we calculated the percentage of each type of reproductive structure (unopened buds, open flowers, and berries) by dividing the number of each particular type of structure by the total number of reproductive structures. Because the percentage of berries per plant seemed most indicative of which reproductive stage a plant was in, we placed each plant in one of the following phenological classes according to percentage of berries: I =0-25%, II = 25-50%, III = >50%.

Using capillary tubes we measured the volume of nectar per ten open flowers. Because the volume of one single flower was too small to measure accurately, we collected nectar from ten flowers and measured the pooled volume. Two such samples were taken from each shrub. We then measured the concentration of nectar (in Brix degrees) of these samples with a refractometer. We compared the volume of nectar per ten flowers and the concentration of that nectar across the phenological reproductive stages.

RESULTS (NDP)

Of the five trees sampled, two were Stage I plants, two were Stage II plants, and the last was a Stage III plant (Table 1).

There was no significant difference in the nectar concentration per flower between the three reproductive phenological stages (F=0.015, df=2,2, P=0.985; Table 2). There was also no significant difference in the nectar volume per flower between the three phenological stages (F=0.250, df=2,2, P=0.800; Table 2).

TABLE 1: Percentage of unopened buds, open flowers, and berries on each *Fuchsia* sp. plant.

Phen stage	Plant #	% buds	% open flowers	% berries
I	1	90.7	9.3	0
I	2	88.9	11.1	0
II	3	62.6	7.5	29.9
II	4	69.7	2.1	28.2
III	5	14.2	7.1	78.8

TABLE 2: Mean nectar concentration/10 flowers and mean nectar volume/10 flowers for each plant of three reproductive phenological stages. n=2 samples of 10 flowers/plant.

Phen stage	Plant #	Nectar conc/10 flowers (±SE) Brix degrees	Nectar vol./ 10 flowers (±SE) (µl)
I	1	26.8 (±0.25)	1.47 (±0.21)
I	2	25.5 (±0.25)	0.60 (±0.0)
II	3	24.5 (±0.50)	0.26 (±0.23)
II	4	25.5 (±0.0)	0.50 (±0.0)
III	5	26.0 (±0.0)	1.25 (±0.74)

DISCUSSION (JMH)

The microhabitats of the five individual plants sampled differed in exposure to sun and wind, amount of available water, amount and type of surrounding vegetation cover, and angle of the slope on which they were growing. To control for the effects of intraspecific competition, we sampled five single plant patches, representing the three phenological stages. That we found only five indicates that single plants may be uncommon in this species of *Fuchsia*. Because they were growing in different microhabitats and these microhabitats are possibly not optimal, those individuals sampled might exhibit different growth patterns, energy allocation, and nectar production from the species norm.

We expected to see an increase in percent open flowers in Stage II. Instead we found that the percentage of open flowers does not change appreciably between the three stages (Table 1). This could be due to (1) our small sample size (n=5); or (2) the possibility that there are actually no differences in the three stages with regard to nectar production. This means an individual plant may not have to distribute its resources over a large number of flowers during Stage II, as we had assumed. The shrub could then keep a

constant nectar volume and concentration through all three stages to attract pollinators. Also, keeping a small but constant number of flowers open at any one time may be a strategy to guarantee that pollinators will continue visiting the plant throughout its entire reproductive period.

Future studies should sample from a larger population of individuals, as well as compare nectar production between multiple plant patches and single plant patches.

During our preliminary observations we found many individuals of both territorial and non-territorial hummingbird species spending large amounts of time around multiplant patches and only a few non-territorial hummingbird species spending shorter periods of time on single plant patches. The relatively unchanging percentage of open flowers across the reproductive phenological stages and the observed hummingbird behavior patterns indicate that there may actually be no difference in nectar concentration or nectar volume between the three phenological stages. Assuming that volume per flower and concentration per flower are constant, hummingbirds would be expected to spend more time at, and be more territorial around, large patches which have an overall greater volume of nectar available in one location. This in fact was the pattern of behavior we observed in our preliminary observations of hummingbirds on *Fuchsia* shrubs at Cerro.